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N. Woodson
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. _____

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TITLE OF THE INVENTION (500 characters max)

DEVICE AND METHOD FOR THE REMOVAL OF HAIR

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ENCLOSED APPLICATION PARTS (check all that apply)

<input checked="" type="checkbox"/> Specification Number of Pages <u>51</u>	<input type="checkbox"/> CD(s), Number _____
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<input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76	

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

<input checked="" type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27.	FILING FEE Amount (\$) <u>80.00</u>
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: _____

[Page 1 of 2]

Respectfully submitted,

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Date 02/24/2004

REGISTRATION NO. 33,621

(if appropriate)

Docket Number: TSI-069

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Docket Number TSI-069

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Number 1 of 1

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DEVICE AND METHOD FOR THE REMOVAL OF HAIR

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FIELD OF THE INVENTION

The present invention relates generally to aesthetic care devices. More particularly the invention is in the field of epilating devices.

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Part 1.

BACKGROUND OF THE INVENTION

The variety of methods existing for hair removal fall into two major categories. Short term hair removal methods remove hair without significantly damaging the biological regeneration and/or re-growth mechanisms found at the base of each hair. Long term and/or permanent and/or irreversible hair removal, on the other hand, affect the biological regeneration and/or re-growth mechanisms of the removed hair, and thus partially and/or permanently inhibit re-growth of unwanted hair from a treated body organ. The most common short term hair removal methods include: manual shaving, mechanical shaving, waxing, rotary mechanical epilation and chemical depilation. The most common long term and/or permanent and/or irreversible hair removal methods include: laser, IPL (Intense Pulsed Light) and electrolysis.

For the purpose of the present invention: short term damage shall be considered generation of any damage to the hair regeneration and/or re-growth mechanisms, where such damage is temporary and is fully recoverable within a typical period of 1 ~ 12 weeks following treatment. Long term damage shall be considered generation of any damage to the hair regeneration and/or re-growth

mechanisms, where such damage is temporary and is materially recoverable within a typical period of 13 – 52 weeks following treatment. Permanent damage shall be considered generation of any damage to the hair regeneration and/or re-growth mechanisms, where such damage partially inhibits at least some of the hair regeneration and/or re-growth mechanisms, and such partial inhibition is permanent. Irreversible damage shall be considered generation of material damage to the hair regeneration and/or re-growth mechanisms, where such material damage fully and permanently inhibits any future growth of hair.

- 10 An optimal hair removal method for generating at least permanent damage and preferably irreversible damage, would be characterized by the following features. Indifference to skin and hair tone – the method should be insensitive to the color of the skin of the treated individual, and/or to the color of the hair of the treated individual, and/or to any combination of the two, so the method shall be similarly
- 15 highly effective for all humans desiring hair removal without exception. High efficacy – the hair treated should not resume any hair growth capabilities after treatment (or series of continuous treatments), and/or the duration between treatments (or between series of continuous treatments) should be long (preferably in excess of 6 months), and per each additional treatment or a series
- 20 of continuous treatments, there would be significant reduction in the number of vital hair remaining within the treated body region. Painlessness – there would be no pain associated with the hair removal method, or the level of pain and/or discomfort associated with hair removal would be insignificant enough to facilitate broad adoption of the method. Negligible side effects and damages –
- 25 there would be minimal and timely transient side effects or damages – both short term and long term - to vital biological tissues beyond the hair mechanism tissues being treated, or any side effects should be transient and preferably disappear within no more than a few days. Convenience – an individual desiring to permanently remove his/her unwanted bodily hair, should be able to
- 30 conveniently do it itself, without the direct or indirect assistance of other individuals and/or hair removal professionals, at any location and time desirable; and; Low operational cost – the overall cost of treating all unwanted bodily hair of a desired body organ and/or all body organs of a single individual, inclusive of all associated direct and indirect expenses such as cost of device, depreciation of

device, cost of disposables / consumables and cost of third party professional labor, should not substantially exceed the cost of short term hair removal methods.

5 Within the hair base, the papilla and hair growth zone (e.g. germinal matrix) play a key role in the hair re-generation and/or re-growth mechanisms. In support of its variety of roles and the hair regeneration / re-growth mechanisms, the papilla integrates tiny blood vessels, which feed the hair regeneration / re-growth mechanisms. Thus, the optimal long term and/or permanent hair removal
10 method would enable a well targeted and full destruction of only the plurality of hair papilla and hair growth zone within the desire body surface in which hair needs to be removed, without negatively affecting any other soft tissues supporting and/or surrounding the hair follicle and/or the hair base.

15 A broad range of attempts have been made to utilize the hair as a wave guide for the transmission of different energy types to the area of the hair root, and as a result, generating sufficient irreversible damage to such region. Following these attempts, it has been scientifically discovered, that human hair has very poor conductivity to almost all types of energies, including: laser, light,
20 radio frequency and electrical energies. Acoustic energy has been discovered to be the type of energy the hair fiber material presents the highest level of conductivity, comparing with other types of energy.

For the purpose of the present invention, acoustic energy shall be considered
25 generation of sonic energy in any frequency between 1 Hertz and 100 Megahertz. Mechanical energy shall be considered combination of generation of sonic energy in any frequency between 1Hertz and 25Kilohertz, and, generation of mechanical power resulting from acoustic and/or mechanical and/or electrical source. Ultrasonic energy shall be considered generation of sonic waves in any
30 frequency in excess of 25 Kilohertz. Thermoacoustic energy shall be considered thermal effects of acoustic energy.

There are significant differences in direct and/or indirect effects, where acoustic energy is utilized, in a broad range of physical characteristics between the hair

fiber material and its supporting and/or surrounding soft biological tissues. These acoustic characteristics include, but not limited to: velocity, conductivity, attenuation and impedance and to thermal properties of hair, whether independent and/or resulting from acoustic energy transfer, such as latent heat capacity and specific heat. etc. Part and/or all of such differences, and its resulting direct and/or indirect effects, could be potentially utilized to the development of new and exciting devices and methods for long term and/or permanent hair removal.

- 10 There exists broad prior art regarding a wide variety of devices and methods regarding hair removal. A relatively small portion of such prior art relates to the utilization of ultrasound technology for hair removal. From such prior art, following are some notable examples: "Method and Apparatus for Hair Removal" (PCT WO 01/13757 A1); "A Method and Device for Affecting an Object by
15 Acoustic Radiation (PCT WO 01/26735 A1), "Method and Device for Hair Removal" (PCT WO 00/21612 A1), "Vibration Depilator" (JP2001029126A2), and, "Depilation Device" (JP8154728A2).

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic description of the method of the present invention

Fig. 2A is a schematic description of the distribution of energy in a device of the present invention

5 Fig. 2B is a schematic description of the distribution of energy in a preferred embodiment of the present invention

Fig. 2C is a schematic description of distribution of energy in another preferred embodiment of the present invention

10 Fig. 2D is a schematic description of distribution of energy in another preferred embodiment of the present invention

Fig. 2E is a schematic description of distribution of energy in another embodiment of the present invention

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GENERAL DESCRIPTION OF THE INVENTION

The present invention presents a device and method for the automated, continuous, concurrent and noninvasive removal of group of hair within hair surfaces designated for removal, by utilizing acoustic and/or thermoacoustic energy and/or mechanical energy for generation of sufficient tissue damaging effects and sufficient detachment.

For the purpose of the present invention, hair soft tissues shall be considered any tissue other than hair fiber material, directly and/or indirectly involved in any hair regeneration and/or hair re-growth and/or hair maintenance mechanisms. Tissue damaging effects to hair soft tissues shall be considered any damage generated, whether short term damage, long term damage, permanent damage and/or irreversible damage, to at least one of hair regeneration mechanisms and/or hair re-growth mechanisms and/or hair surrounding tissues and/or hair supporting tissues. Sufficient tissue damaging effects shall be considered damages to hair tissues resulting from acoustic energy and/or thermoacoustic energy and/or mechanical energy, where such damages, are at the minimum long term damages, preferably permanent damages and optimally irreversible damages, primarily result in targeted damages to the specific tissues involved in the hair regeneration and/or re-growth mechanisms, but no damage and/or minimal and timely transient damage to soft tissues not involved in such mechanisms and/or involved in support of additional biological mechanisms beyond hair mechanisms. Sufficient detachment shall be considered structural modifications in different hair systems, in the hair shaft, hair follicle and/or hair base, resulting from acoustic energy and/or thermoacoustic energy and/or mechanical energy, which enable practically painless pulling-out of such treated hair with a torque smaller in at least 50% from the torque required to detach such hair prior to its treatment by acoustic energy and/or thermoacoustic energy and/or mechanical energy.

The target of the invention is to concurrently generate sufficient long term and/or permanent damage and/or irreversible damage to groups of hair bases

(e.g. the follicle, papilla and blood vessels connected to the papilla of each hair base) within hair surfaces designated for hair removal. Such long term and/or permanent and/or irreversible damage to groups of hair bases is generated by some and/or all of a broad range of physical effects resulting from direct and/or indirect effects of the utilization of group of hair as conductors of acoustic energy and/or thermoacoustic energy and/or mechanical energy, and its influence / impact on these hair bases. Such effects are a result of broad range of differences in physical characteristics in the response to acoustic energy between the fiber materials comprising the hair and its supporting and/or surrounding soft biological tissues. For the purpose of the present invention, differences in physical characteristics relating to acoustic energy and/or thermoacoustic energy transfer through hair as conductor include at least: velocity, impedance, conductivity, attenuation, absorption and/or returns.

By utilizing plurality of hairs as conductors of acoustic energy and/or thermoacoustic energy and/or mechanical energy, the present invention is minimally sensitive and/or fully insensitive to several physiological parameters of the treated person such as: skin color tone, hair color tone and/or level of contrast between skin color tone and hair color tone. Devices and methods for long term and/or permanent hair removal making use of other energy types not utilizing the plurality of treated hairs as conductors of energy, such as laser and/or light and/or electromagnetic and/or radio frequency and/or X-ray, etc. (even when combined together or combined with other techniques), are significantly sensitive to such color tone parameters. Thus, the proposed device and method are capable of treating significantly larger populations comparing with such other hair removal methods, where such larger populations include, but not limited to: individuals with dark skin tone; and; individuals with very light hair tone and/or minimal amount of melanin in the hair.

The long term and/or permanent and/or irreversible damage generated to each hair base is the result of at least one or more of the following direct and/or indirect effects of acoustic energy and/or thermoacoustic energy and/or

mechanical energy transfer to the plurality of hair bases through plurality of hairs serving as conductors for acoustic energy transmission: thermal effects of acoustic energy, mechanical effects of acoustic energy, and; chemical effects of acoustic energy.

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For the purpose of the present invention, thermal effects of acoustic energy shall be considered at least elevation in the temperature of hair fiber material, which affects its supporting and/or surrounding soft tissues, and, elevation of the temperature of hair supporting and/or surrounding soft tissues, as a result of acoustic energy passage through hair as conductor. Mechanical effects of
10 acoustic energy shall be considered at least one of the following effects: cavitation, vibration, micro-vibration, shock, and/or jet. Chemical effects of acoustic energy shall be considered modifications, at the molecular structure level, of hair regeneration and/or re-growth and/or maintenance mechanisms,
15 and; soft tissues supporting and/or surrounding hair being treated.

There are a variety of differences between the physical characteristics of the hair fiber material and its surrounding and/or supporting soft biological tissues. Two, but not limited to, such characteristics are notable: (a) The heat buildup
20 of the hair fiber material as a result of absorption of acoustic energy is significantly higher than the heat distributed along the surrounding air and/or surrounding and/or supporting soft biological tissues (b) The acoustic impedance of the hair fiber material is significantly higher than the acoustic impedance of its surrounding and/or supporting soft biological tissues. The
25 present invention takes advantage of these two phenomena, as well as of a variety of other direct and/or indirect effects of acoustic energy transfer through the hair fiber material, to effectively generate long term and/or permanent and/or irreversible damages to the plurality of hair bases being treated per cycle by the proposed device and method.

30

The key to the generation of long-term damage and/or permanent damage and/or irreversible damage to the hair regeneration / re-growth mechanisms involves material and/or irreversible destruction of the papilla and/or the hair growth zone (e.g. germinal matrix) at the hair base. In order to generate such

level of long term damage and/or permanent damage and/or irreversible damage to the hair regeneration/re-growth mechanisms, there is a need to elevate the temperature at the bottom of the hair base in order to generate material and/or irreversible tissue damage effects to the papilla and/or hair growth zone.

Thus, the present invention also takes advantage of the proximity of the hair papilla to the hair fiber material and germinal matrix at the hair base, specially, but not limited to, during the hair Anagen growth phase, to exploit the variety of direct and/or indirect effects (mostly and primarily thermal effects complemented by mechanical effects) resulting from acoustic energy transmission through hair as a conductor. When integrated within the hair base, and taking into account the very small volume of the papilla (several hundreds of cubic microns), a rapid and short increase in the temperature of the fiber material of the hair as a result of acoustic energy transfer through the hair, shall timely elevate the generation of sufficient thermal effects and/or thermoacoustic effects and/or mechanical effects at the germinal matrix and/or the papilla, sufficient enough to cause material and/or irreversible tissue damage to such small volumes of biological tissue/s. Such direct and/or indirect thermal effects and/or mechanical effects and/or chemical effects shall be short enough in its duration, per each single hair from a group of hair being gripped and serving as a conductor for acoustic and/or thermoacoustic energy and/or mechanical energy, to generate such selective material and/or irreversible tissue damage to the germinal matrix and/or the papilla, yet generating none or minimal and timely transient side effects to other soft biological tissues supporting and/or surrounding the hair fiber material utilized as a conductor for acoustic and/or mechanical energy.

The long term and/or permanent and/or irreversible damage generated to each hair base of the group of hair being treated concurrently, also facilitates partial and/or significant detachment of group of hair from its hair bases with similar or lesser pain / discomfort and similar or lesser torque comparing with some existing hair removal methods.

The acoustic energy, transferred to the group of hair bases via a group of hair serving as conductors, is controllable in a variety of parameters which can be automatically sensed (via a broad range of sensor types which can be incorporated into the device), set and dynamically controlled and/or adjusted by the device and/or set and controlled manually by the person using the device. Parameters of the acoustic energy may include some or all of the following: frequencies, amplitudes, transmission modes (continuous or intermittent), wave types (longitudinal, transverse, torque, sheer, flexural, etc.) and/or transmission durations. Parameters of the gripping mechanism may include some or all of the following: hair gripping methods, hair coupling methods, hair coupling forces, hair detachment forces, directional and/or rotational velocity, angles, etc. The partial and/or meaningful optimization of the combination of acoustic energy transmission parameters, mechanical energy transmission parameters, hair gripping parameters and hair acoustic coupling parameters, enable sufficiently effective utilization of acoustic and/or mechanical energy transfer and its direct and/or indirect effects through the hair as an acoustic energy conductor even when the hair not fully stretched (e.g. the hair may be slightly and/or meaningfully bent). This means, that in the proposed rotational gripping, acoustic and/or mechanical energy transfer mechanism of the present invention, acoustic energy and/or thermoacoustic energy and/or mechanical energy transfer through group of hair serving as energy conductors can potentially start in concert with its gripping. This leaves a wider time window for generating sufficient long term and/or permanent and/or irreversible damage through acoustic energy, thermal effects and/or thermoacoustic effects and/or mechanical effects to each hair base being treated. Such capability is amongst the plurality of improvements of the present invention comparing with prior art of utilizing a human hair as a wave guide of acoustic energy transfer, which requires substantial, hair-by-hair stretching prior to effective energy transfer.

30

The setup of acoustic and/or mechanical energy parameters may be tuned and/or adjusted according to one or more of the following physiological parameters characterizing the person being treated and/or the body organ being treated with the device: hair growth phase (e.g. Anagen, Catagen or

Telogen), depth of the hair base under the skin, distance between hair base and papilla, total hair length (e.g. under the skin and above the skin), hair coupling angle, hair color, hair diameter, force required to detach a vital untreated hair from vital untreated hair base, force required to detach a hair
5 from a partially treated hair base and/or force required to detach a hair from fully treated and materially destroyed hair base.

The tuning and/or adjustment of acoustic and/or mechanical energy parameters to the physiological parameters of the treated person, are
10 targeting the reduction of temporary and/or long term side effects to vital biological tissues in proximity to the group of hair and/or hair bases being treated, comparing with some existing hair removal methods.

Further, the tuning and/or adjustment of acoustic and/or mechanical energy
15 parameters to the physiological parameters of the treated person, are targeting the reduction of the necessary per-single hair duration required to generate sufficient long-term and/or permanent damage to treated hair base, comparing with other long term and/or permanent and/or irreversible hair removal methods.

20 The device of the present invention, facilitates automated, continuous, concurrent and noninvasive removal of group of hair within hair surfaces designated for removal, by utilizing acoustic and/or thermoacoustic energy and/or mechanical energy for generation of sufficient tissue damaging effects
25 and sufficient detachment.

For the purpose of the present invention, acoustic coupling shall mean generation of physical contact between group of treated hair and an acoustic energy source and/or interface to acoustic energy source, for facilitation of
30 transfer of acoustic energy from such acoustic energy source and/or interface to such group of hair. Acoustic energy losses shall mean the total amount of energy generated by acoustic energy source, but not transferred to group of hair being treated. Minimal acoustic energy losses shall mean a certain percentage of acoustic energy losses, where such losses are not greater than

90% from amount of acoustic energy generated, and where remaining energy is sufficient for generating sufficient tissue damaging effects and sufficient detachment. Effective transfer of acoustic energy shall mean that no less than 10% from the amount of acoustic energy generated by the acoustic energy source of the device of the invention, is transferred to the hair group being treated. Hair removal cycle shall mean cycle of removing a single group of hair, comprising at least of: predisposition of group of hair; gripping group of hair; acoustic coupling of group of hair; transferring acoustic energy to group of hair; transferring mechanical energy to group of hair; pulling out group of hair; and/or; releasing such group of hair.

Per each group of hair being treated by the device, the device facilitates at least: predisposition of such group of hair for optimizing its gripping and acoustic coupling; gripping of hair; acoustic coupling of hair; utilization of acoustic energy for generation of sufficient tissue damaging effects; utilization of mechanical energy for generation of sufficient detachment; and/or; pulling out group of hair after generation of sufficient tissue damaging effects and sufficient detachment. The device may potentially facilitate releasing of group of hair after its pulling out.

The device further facilitates concurrent treatment of a plurality of group of hair, where each group of hair may be in an earlier step or a similar step of its preceding group of hair, per the following steps: predisposition; gripping; acoustic coupling; transfer of acoustic energy; transfer of mechanical energy; and/or pulling out group of hair.

The device of the invention is comprised from at least system for predisposition of group of hair, system for gripping and pulling out of group of hair, system for interfacing ultrasonic energy to group of hair, system for ultrasonic energy generation, system for mechanical energy generation, system for electrical energy generation, system for data management, system for body surface tracking and/or system of sensors.

The system for predisposition of group of hair, is integrated into the device of the invention. While the device moves over designated body surface for hair removal, the system for predisposition controls at least one of modification of angle of attack of group of hair for improving optimization of gripping and acoustic coupling; maintaining sufficient gap between treated body surface
 5 and device for eliminating and/or minimizing damages and/or side effects; cooling and/or soothing body surface during predisposition; and/or; cooling and/or soothing such part of treated body surface following treatment.

10 The system for data management, is responsible for any and all data acquisition, processing, control and management of the device of the invention. Such system for data management is comprised of at least one subsystem for data processing; one subsystem for data display; one subsystem for data entry; one subsystem for data acquisition; and/or one
 15 subsystem for control of device systems and/or subsystems. The subsystem for data processing incorporates at least one of general purpose CPU and at least one of special purpose processing unit designed and built for the device of the invention. The subsystem for data display incorporates at least one display which is capable of presenting data acquired and/or generated by the
 20 device, in an alphanumeric and/or graphical manner. The subsystem for data entry incorporates at least one multi-choice selection button and/or at least one mechanism for free data entry by person using the device. The subsystem for data acquisition incorporates acquisition of at least one sensor from system of sensors. The subsystem for control incorporates and facilitates
 25 at least one of control of at least one device component and/or function per pre-defined parameters and/or control of at least one device component and/or function per data acquired and/or processed by device in real-time.

The system of sensors incorporates at least one of a broad range of sensors
 30 which enable real-time reporting of a broad range of functional and/or operational aspects of the device of the invention during hair removal process. Such system of sensors shall incorporate at least one of temperature sensors, torque sensors, image processing sensors and/or energy quantification sensors

The system for body surface tracking is designated for performing and/or regulating the movement of the device of the body region being treated. It is comprised from at least one of cylindrical and/or wheel element, which can be
5 powered by at least one of system for electrical energy generation; system for mechanical energy generation; electric motor integrated into system for body surface tracking; and/or; manual powering by hand of person using the device.

10 Per one of the preferred embodiments of the invention, a cylindrical piezoelectric element incorporates the ultrasonic energy generation system and the mechanical energy generation system; and; a hollow cylindrical element is incorporating the system for gripping and pulling out of group of hair and system for interfacing acoustic energy to group of hair.

15 The cylindrical piezoelectric element is a key component within this preferred embodiment of the present invention. Such piezoelectric element incorporate a broad variety of functions and capabilities, and thus eliminates the need to incorporate and integrate at least some of the plurality of components such as
20 electric motor and/or mechanical power transmission components and/or acoustic energy generators and/or mechanical energy generators. The piezoelectric element generates at least one low frequency lower than 25 Kilohertz and at least one high frequency greater than 25 Kilohertz, where at least one such low frequency is utilized for the generation, by the piezoelectric
25 element, of rotational movement and/or mechanical energy required to power different systems of the device and/or mechanical effects of acoustic energy necessary for generation of sufficient tissue damaging effects and/or sufficient detachment. The high frequency generated by the piezoelectric element is utilized for generation of thermal effects of acoustic energy and/or
30 thermoacoustic effects of acoustic energy and/or mechanical effects of acoustic energy, targeting generation of sufficient tissue damaging effects and/or sufficient detachment. Thus, the piezoelectric element concurrently operates as at least a rotational motor with sufficient torque to pull-out hair after generation of sufficient tissue damaging effects and/or detachment

effects, and at the same time generates at least one type of acoustic energy and/or mechanical energy for generation of sufficient tissue damaging effects and sufficient detachment through thermal effects of acoustic energy and/or thermoacoustic effects of acoustic energy and/or mechanical effects of acoustic energy. The cylindrical piezoelectric element can also generate two or more types of acoustic energy, where each energy is characterized by at least one different parameter of frequency, amplitude, transmission mode, wave type, and/or duration. Thus, each of the at least two concurrent energy types is capable of generating different tissue damaging effects and/or hair detachment effects. In the preferred embodiment, the cylindrical piezoelectric element also powers system for body tracking. The cylindrical piezoelectric element is so designed, that acoustic energy it generates is transmitted primarily from its outer surface and minimally from its sides. In mass production, the direct manufacturing cost of a single piezoelectric element incorporated into the preferred embodiment of the device of the present invention should be well below \$25US.

The hollow cylindrical element, incorporating system for gripping and pulling out hair and system for interfacing acoustic energy to group of hair, is also a key component within this preferred embodiment of the present invention. This hollow cylindrical element, which tightly envelopes the cylindrical piezoelectric element, is the prime device component which performs most of the contact with group of hair designated for removal. This element incorporates at least one of gripping group of hair; acoustically coupling group of hair; interfacing ultrasonic energy to group of hair; interfacing mechanical energy to group of hair; pulling out group of hair and/or releasing group of hair. This element is always firmly coupled to the cylindrical piezoelectric element, so the rotational movement of the cylindrical piezoelectric element similarly powers and rotates the hollow cylindrical element. This hollow cylindrical element can be permanently attached to the device, or can be a replaceable element as one of several hollow cylindrical elements, each serving a different hair removal task per one or more of the following treated person parameters: body region being treated, hair diameter, hair length, hair color, torque required to pull out vital hair prior to treatment and/or torque

required to pull out hair after treatment. This hollow cylindrical element can also be of a multi-use long term nature, or of a disposable nature, designed for a limited number of uses. For the purpose of successfully delivering the broad variety of its functions, this hollow cylindrical element incorporates at
5 least one of material or materials optimal for acoustic coupling; mechanism or mechanisms for rapid gripping of group of hair; material or materials with adhesive characteristics, for facilitation of improved gripping of group of hair and/or acoustic coupling of group of hair; mechanism or mechanisms for rapid pulling out of hair after generation of sufficient tissue damaging effects and
10 sufficient detachment; and/or mechanism for rapid release of group of hair, after pulling out group of hair.

In another preferred embodiment of the present invention, an electric motor incorporates system for mechanical energy generation, a piezoelectric
15 element incorporates system for acoustic energy generation, and a mechanical rotary hair gripping element incorporates both system for gripping and pulling out group of hair and system for interfacing acoustic energy to group of hair.

20 According to such preferred embodiment of the present invention, the mechanical rotary hair gripping element incorporates at least one of gripping group of hair; acoustically coupling group of hair; interfacing ultrasonic energy to group of hair; interfacing mechanical energy to group of hair; pulling out group of hair and/or releasing group of hair. This mechanical rotary hair
25 gripping element is further optimized for at least one of effective and/or rapid gripping of group of hair; effective and/or rapid coupling of group of hair; effective and/or rapid interfacing of acoustic energy to group of hair; effective and/or rapid interfacing of mechanical energy to group of hair; effective and/or rapid pulling out of group of hair; and/or; effective and/or rapid release of
30 group of hair. The mechanical rotary hair gripping element can be permanently affixed to the device or can be detachable or can replaceable. In this preferred embodiment, the electric motor is directly powering the mechanical rotary hair gripping element, and the piezoelectric element

powers, in parallel, the mechanical rotary hair gripping element with acoustic energy.

5 In another preferred embodiment of the invention, the electric motor powers the piezoelectric element with mechanical energy, and such powering facilitates the powering of the mechanical rotary hair gripping element with both mechanical energy and acoustic energy by the piezoelectric element.

10 In another preferred embodiment of the invention, the electric motor powers the system for body tracking.

15 In another embodiment of the present invention, the electric motor mechanically powers the piezoelectric element, which then powers the system for body tracking.

DETAILED DESCRIPTION OF THE PRESENT INVENTION

In accordance with the present invention, hair is removed by the application of thermoacoustic and/or acoustic and/or mechanical energy to the targeted hair of a subject person, causing a minimal discomfort to the subject being treated and ensuring long term or permanent loss of hair and/or hair regeneration capabilities at the targeted skin portion. Reference is made to **Fig. 1** which explains schematically the sequence of part or all of the steps carried out in the process of hair removal in accordance with the invention. In step **20** the device of the invention is applied to the skin, in step **22** group of hair is predisposed for gripping, in step **24** a group of designated hair is gripped and acoustically coupled. In step **26** acoustic and/or mechanical energy in a specification as will be discussed later on, is applied to the gripped group of hair. In step **28** the gripped group of hair is pulled out, and in step **30** the pulled group of hair is released.

In **Fig. 2A** the energy allocation application scheme of the method of the invention is explained schematically, and in most general terms. A generalized acoustic and mechanical energy source **40**, provides acoustic and mechanical energy to four consumers: the epilation device tracker unit **42**, a hair gripper and puller unit **44**, a hair generative tissue destructing interface unit **46**, and a hair predisposer unit **48**. The acoustic and mechanical energy source is a generalized term relating to one or more physical units, each of which is a transducer of energy, converting electric energy to acoustic energy and/or mechanical energy, except when human force is employed as will be explained later on.

In **Fig. 2B** the energy allocation and application is described with regards to preferred embodiment A. In this case, the acoustic and mechanical energy source is a piezoelectric transducer **60**, which provides mechanical energy for the epilation device tracker unit **62**, provides acoustic energy and/or mechanical energy for the hair gripper unit **64**, provides acoustic energy and/or mechanical energy for the hair generative tissue destructive interface unit **66** and/or provides mechanical energy for the hair predisposer unit **68**.

In preferred embodiment B, the acoustic and mechanical energy source combines two units and the allocation of energy is described in **Fig. 2C** to which reference is now made. In this embodiment, the acoustic and mechanical energy source **80** includes two different units, an electric motor **82** and a piezoelectric transducer **84**. Electric motor **82**, transduces electric energy into rotational mechanical torque, and provides mechanical energy for the wheels of the tracker unit **86**, provides mechanical energy for the hair gripper and puller unit **88** and/or provides mechanical energy for the hair predisposer unit **92**. Piezoelectric transducer **84** provides acoustic energy for the generative tissue destructor interface unit **90** and/or provides acoustic energy for the hair gripper and puller unit **88**.

In another embodiment, described schematically in **Fig. 2D** to which reference is now made, an electric motor **100** transduces electric energy into rotational mechanical torque, and provides mechanical energy for the wheels of tracker unit **104**, provides mechanical energy for the piezoelectric transducer **102** and/or for the hair predisposer unit **110**. Piezoelectric transducer **102** provides acoustic energy and/or mechanical energy for the hair gripper and puller unit **106**, and provides acoustic energy and/or mechanical energy for the hair generative tissue destructor interface unit **108**.

In another embodiment, described schematically in **Fig. 2E** to which reference is now made, an electric motor **120** transduces electric energy into rotational mechanical torque, and provides mechanical energy for the piezoelectric transducer **122**. Piezoelectric transducer **120** provides mechanical energy to several consumers: the tracker unit **124**, acoustic and/or mechanical energy to the hair gripper and puller unit **126**, acoustic and/or mechanical energy to the hair generative tissue destructor interface unit **128** and/or des mechanical energy for the hair predisposer unit **130**.

CLAIMS

1. A method for the removal of hair comprising the steps of:
 - 5 • selecting a skin surface;
 - predisposing for gripping a group of hair within said designated skin surface;
 - gripping said group of hair;
 - coupling said group of hair for acoustic energy transfer;
 - 10 • transferring acoustic energy, to said group of hair, for generation of sufficient tissue damaging effects to said group of hair;
 - transferring mechanical energy, to said group of hair, for causing sufficient detachment of said group of hair, and
 - pulling out said group of hair from said skin surface.
- 15 2. A method according to claim 1, wherein said hair removal method is rotational method for hair removal
3. A method according to claim 1, wherein said hair removal method is
20 automated
4. A method according to claim 1, wherein transition between the different steps of said hair removal method is partially automated and partially manual
- 25 5. A method according to claim 1, wherein transition between said steps is sequential
6. A method according to claim 1, wherein said steps of gripping said
30 group of hair and coupling said group of hair are concurrent
7. A method according to claim 1, wherein said steps of transferring acoustic energy and transferring mechanical energy are concurrent

8. A method according to claim 1, wherein said steps of transferring acoustic energy, transferring mechanical energy and pulling out said hair are concurrent
- 5 9. A method according to claim 1, wherein all of hair removal method steps are concurrent
- 10 10. A method according to claim 1, wherein hair removal process is noninvasive
11. A method according to claim 1, wherein said predisposition changes the angle of attack of said group of hair
- 15 12. A method according to claim 1, wherein each said hair of said group of hair is serving as a conductor of acoustic energy and/or mechanical energy
- 20 13. A method according to claim 1, wherein said group of hair is at least partially tensioned prior to effective transfer of acoustic energy and/or mechanical energy
- 25 14. A method according to claim 1, wherein said group of hair is not tensioned prior to effective transfer of acoustic energy and/or mechanical energy
15. A method according to claim 1, wherein tissue damaging effects result in irreversible damage generation to said group of hair
- 30 16. A method according to claim 1, wherein tissue damaging effects result in at least permanent damage generation to said group of hair
17. A method according to claim 1, wherein tissue damaging effects result in at least long term damage generation to said group of hair

18. A method according to claim 1, wherein tissue damaging effects result in at least short term damage generation to said group of hair
- 5 19. A method according to claim 1, wherein tissue damaging effects result in rapid damage generation to pain sensing nerves of said group of hair, thus eliminating and/or materially minimizing the pain and/or discomfort associated with said hair removal method
- 10 20. A method for removing a group of hair comprising:
- selecting a skin surface;
 - predisposing a group of hair to be removed within said selected skin surface;
 - gripping said group of hair;
 - 15 • coupling said group of hair for acoustic energy transfer;
 - transferring acoustic energy, to said group of hair, for generation of sufficient tissue damaging effects to said group of hair;
 - transferring mechanical energy, to said group of hair, for causing sufficient detachment of said group of hair, and
 - 20 • pulling out said group of hair from said skin surface after generating said sufficient tissue damaging effects and said sufficient detachment.
21. A method according to claim 20, wherein said hair removal method is
- 25 rotational method for hair removal
22. A method according to claim 20, wherein said hair removal method is automated
- 30 23. A method according to claim 20, wherein transition between the different steps of said hair removal method is partially automated and partially manual

24. A method according to claim 20, wherein transition between said steps is sequential
- 5 25. A method according to claim 20, wherein each different group of said plurality of group of hair is concurrently at a different step of said hair removal method
- 10 26. A method according to claim 20, wherein at least one group of said plurality of group of hair is concurrently at a different step of said hair removal method
- 15 27. A method according to claim 20, wherein at least two groups of said plurality of group of hair is concurrently at a similar step of said hair removal method
- 20 28. A method for hair removal, utilizing thermal effects of acoustic energy for elevation of hair temperature and generation of sufficient tissue damaging effects and/or sufficient detachment
29. A method according to claim 28, wherein said hair fiber material is utilized as conductor of acoustic energy
- 25 30. A method according to claim 28, wherein said thermal effects of acoustic energy are resulting from differences in physical characteristics between said hair fiber material and said hair soft tissues
- 30 31. A method for hair removal by utilizing mechanical effects of acoustic energy for generating sufficient tissue damaging effects and/or sufficient detachment through elevation of hair temperature
32. A method according to claim 31, wherein said hair fiber material is utilized as conductor of acoustic energy

33. A method for hair removal by utilizing chemical effects of acoustic energy for generating sufficient tissue damaging effects and/or sufficient detachment
- 5 34. A method according to claim 33, wherein said hair fiber material is utilized as conductor of acoustic energy
35. A device for removing group of hair from a surface of a body, comprising at least:
- 10 35.1. system for predisposition of said group of hair
35.2. system for gripping and pulling out said group of hair
35.3. system for interfacing acoustic energy to said group of hair
35.4. system for mechanical energy generation
35.5. system for acoustic energy generation
15 35.6. system for electric energy generation
35.7. system for data management
35.8. system for body surface tracking
35.9. system of sensors
- 20 36. A device according to claim 35, wherein said hair removal device operates through hair removal cycles, whereas each cycle begins with predisposition of said group of hair and ends with the release of said group of hair
- 25 37. A device according to claim 35, wherein said hair removal device facilitates rotational method of hair removal
38. A device according to claim 35, wherein said system for predisposition of said group of hair, while said hair removal device moves over
30 designated body surface containing hair, controls at least one of:
- 38.1. modification of the angle of attack of said group of hair, for optimizing its gripping and/or its acoustic coupling
38.2. maintenance of sufficient spacing between said surface of a body being treated and such said device elements generating heat

and/or mechanical energy, for avoiding damage and/or side effects
to said surface of body being treated

38.3. cooling the part of said surface of body being predisposed for
treatment

5 38.4. cooling the part of said surface of body already treated

39. A device according to claim 35, wherein said system for data
management incorporates at least one of:

- 39.1. at least one subsystem for data processing
- 10 39.2. at least one subsystem for data display
- 39.3. at least one subsystem for data entry
- 39.4. at least one subsystem for data acquisition
- 39.5. at least one subsystem for components control

15 40. A device according to claim 39, wherein said subsystem for data
processing incorporates at least one general purpose CPU and/or at
least one special purpose data processing unit specifically designed for
said hair removal device

20 41. A device according to claim 39, wherein said subsystem for data display
incorporates at least alphanumeric display and/or graphic display

42. A device according to claim 39, wherein said subsystem for data entry
subsystem incorporates at least one multi-choice selector button for pre-
25 defined options entry and/or one keypad for free data entry by person
using said device

43. A device according to claim 39, wherein said subsystem for data
acquisition acquires, in real-time, data generated by at least one sensor
30 of said system of sensors

44. A device according to claim 39, wherein said subsystem for components
control facilitates at least:

- 44.1. control of at least one operational and/or functional characteristics of said hair removal device, per pre-defined parameters
 - 44.2. control of at least one operational and/or functional characteristics of said hair removal device, per parameters acquired in real-time from said subsystem of sensors and processed by said subsystem for data processing
- 5
- 45. A device according to claim 39, wherein said system of sensors incorporates at least:
 - 10 45.1. at least one sensor for measuring temperature of said treated body surface
 - 45.2. at least one sensor for measuring temperature of said hair roots being treated
 - 45.3. at least one sensor for measuring temperature of said hair fiber being treated
 - 15 45.4. at least one sensor for measuring diameter of said hair being treated
 - 45.5. at least one sensor for measuring color tone of said hair being treated
 - 20 45.6. at least one sensor for measuring pull-out torque of said vital hair prior to treatment
 - 45.7. at least one sensor for measuring said treated hair pull-out torque of hair after treatment
 - 45.8. at least one sensor for measuring temperature of said device components
 - 25 45.9. at least one sensor for measuring parameters of acoustic energy generation by said device
 - 45.10. at least one sensor for measuring parameters of mechanical energy and/or forces generation by said device
 - 30 45.11. at least one sensor for measuring parameters of electric energy generation by said device
 - 46. A device according to claim 35, wherein said system for body surface tracking, is comprised of at least one cylindrical and/or wheel element in

contact with the skin of said surface of body being treated, and controlling and/or regulating the movement direction and velocity of said device over said surface of body, whereas said cylindrical and/or wheel element is powered by at least one of:

- 5 46.1. said system for mechanical energy generation
 - 46.2. said system for electric energy generation
 - 46.3. electric motor integrated into said system for body surface tracking
 - 46.4. manual power generated by the hand of the person using said device
- 10 47. A device according to claim 34, wherein at least one cylindrical piezoelectric element incorporates both said system for mechanical energy generation and said system for acoustic energy generation and; at least one hollow cylindrical element incorporates both said system for
- 15 gripping and pulling out group of hair and said system for acoustic energy interfacing
48. A device according to claim 47, wherein said cylindrical piezoelectric element generates both acoustic energy and mechanical energy
- 20 49. A device according to claim 47, wherein said cylindrical piezoelectric element concurrently operates in at least two frequencies:
- 49.1. at least one frequency for generation of at least one of rotational movement and/or mechanical effects of acoustic energy
 - 25 49.2. at least one frequency for generation of a combination of at least one of mechanical energy and/or ultrasonic energy and/or thermal effects of acoustic energy and/or thermoacoustic effects of acoustic energy and/or chemical effects of acoustic energy
 - 49.3. at least one frequency for generation of at least one of chemical
 - 30 effects of acoustic energy
50. A device according to claim 47, wherein generation of mechanical energy and acoustic energy by said cylindrical piezoelectric element, is exercised by at least one of:

- 50.1. concurrent generation of said mechanical energies and said acoustic energies
 - 50.2. intermittent generation of said mechanical energies and said acoustic energies
 - 5 50.3. patterned generation of said mechanical energies and said acoustic energies
51. A device according to claim 47, wherein said hollow cylindrical element incorporates at least one of:
- 10 51.1. gripping said group of hair
 - 51.2. acoustic coupling of said group of hair
 - 51.3. interfacing acoustic energy transfer to said group of hair
 - 51.4. interfacing mechanical energy transfer to said group of hair
 - 51.5. pulling out said group of hair
 - 15 51.6. releasing said group of hair
52. A device according to claim 47, wherein said hollow cylindrical element envelopes said cylindrical piezoelectric element, and said hollow cylindrical element is firmly coupled to said cylindrical piezoelectric element during device operation
- 20
53. A device according to claim 47, wherein rotational movement of said cylindrical piezoelectric element concurrently powers rotational movement of said hollow cylindrical element
- 25
54. A device according to claim 47, wherein said hollow cylindrical element incorporates at least one of:
- 30 54.1. material or materials optimal for acoustic coupling and acoustic energy transfer to said group of hair with minimal acoustic energy losses
 - 54.2. mechanism or mechanisms for rapid gripping of said group of hair
 - 54.3. material or materials with adhesive characteristics for facilitation of improved gripping and acoustic coupling of said group of hair

- 54.4. mechanism or mechanisms for rapid pulling out of said group of hair after generation of sufficient tissue damaging effects and sufficient detachment of said group of hair
- 54.5. mechanism or mechanisms for rapid release of said group of hair after generation of sufficient tissue damaging effects and sufficient detachment of said group of hair
55. A device according to claim 47, wherein said hollow cylindrical element is designed for long term multi-use
56. A device according to claim 47, wherein said hollow cylindrical element is disposable
57. A device according to claim 47, wherein said hollow cylindrical element is affixed to said device
58. A device according to claim 47, wherein said hollow cylindrical element is detachable from said device and/or replaceable
59. A device according to claim 47, wherein said mechanical energy generated by said cylindrical piezoelectric element also powers said system for body surface tracking
60. A device according to claim 35, wherein said system for mechanical energy generation is an electric motor, and; said system for acoustic energy generation system is a piezoelectric element, and; a mechanical rotary hair gripping element incorporates both said system for hair gripping and pulling out of said group of hair and said system for acoustic energy interfacing
61. A device according to claim 60, wherein said mechanical rotary hair gripping element incorporates at least one of:
- 61.1. gripping said group of hair
- 61.2. acoustic coupling of said group of hair

- 61.3. interfacing acoustic energy transfer to said group of hair
- 61.4. interfacing mechanical energy transfer to said group of hair
- 61.5. pulling out said group of hair
- 61.6. releasing said group of hair

5

62. A device according to claim 60, wherein said mechanical rotary hair gripping element is optimized for at least one of:

- 62.1. effective and/or rapid gripping of said group of hair
- 62.2. effective and/or rapid acoustic coupling of said group of hair
- 10 62.3. effective and/or rapid interfacing of acoustic energy to said group of hair
- 62.4. effective and/or rapid interfacing of mechanical energy to said group of hair
- 62.5. effective and/or rapid pulling out of said group of hair
- 15 62.6. effective and/or rapid release of said group of hair

63. A device according to claim 60, wherein said mechanical rotary hair gripping element is affixed to said device

20 64. A device according to claim 60, wherein said mechanical rotary hair gripping element is detachable from said device, and/or replaceable

65. A device according to claim 60, wherein mechanical energy generation by said electric motor powers a rotational movement of said mechanical rotary hair gripping element, and acoustic energy generation by said piezoelectric element powers the acoustic interfacing capabilities of said mechanical rotary hair gripping element

30 66. A device according to claim 60, wherein mechanical energy generation by said electric motor powers rotational movement of said piezoelectric element, whereas combined with acoustic energy generated by piezoelectric element, said piezoelectric element concurrently powers said mechanical rotary hair gripping element with mechanical energy and acoustic energy

67. A device according to claim 59, wherein the mechanical energy generated by said electric motor also powers said system for body surface tracking

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68. A device according to claim 59, wherein the mechanical energy generated by said electric motor powers said piezoelectric element, which then mechanically powers said system for body surface tracking

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Part 2.

20

BACKGROUND OF THE INVENTION

The variety of devices and methods existing to date for hair removal can be divided into two major categories: Short term hair removal and long term hair removal.

25 Short term hair removal devices and methods remove hair without significantly damaging the biological regeneration and/or re-growth mechanisms found at the base of each hair.

30 Long term and/or permanent and/or irreversible hair removal devices and methods, on the other hand, affect the biological regeneration and/or re-growth mechanisms of the removed hair, and thus partially and/or permanently inhibit re-growth of unwanted hair from a treated body organ. The most common short term hair removal methods include: manual shaving utilizing a blade, mechanical

shaving (e.g. hair shaving appliance), waxing, rotary mechanical epilation and chemical depilation. The most common long term and/or permanent and/or irreversible hair removal methods include: light irradiation with laser, IPL (Intense Pulsed Light) and electrolysis.

5

Short term damage shall be considered generation of any damage to the hair regeneration and/or re-growth mechanisms, where such damage is temporary and is materially recoverable within a typical period of 1 – 12 weeks following a single treatment.

10

Long term damage shall be considered generation of any damage to the hair regeneration and/or re-growth mechanisms, where such damage is temporary and is materially recoverable within a typical period of 13 – 52 weeks following treatment.

15

Permanent damage shall be considered generation of any damage to the hair regeneration and/or re-growth mechanisms, where such damage partially inhibits at least some of the hair regeneration and/or re-growth mechanisms, and such partial inhibition is permanent (e.g. life long). Irreversible damage shall be considered generation of material damage to the hair regeneration and/or re-growth mechanisms, where such material damage fully and permanently inhibits any future growth of hair.

20

An optimal hair removal method for generating at least long term damage and preferably permanent or irreversible damage would be characterized by the following features:

25

- a. Indifference to skin and hair tone – the method should be insensitive to the color of the skin of the treated individual, or to the color of the hair of the treated individual, and preferably to any combination of the two, so the method shall be similarly highly effective for all humans desiring hair removal without exception.
- b. High efficacy – the hair treated should not resume any hair growth capabilities after treatment (or series of continuous treatments), and/or the duration between treatments (or between series of

30

continuous treatments) should be long (preferably in excess of 6 months), and per each additional treatment or a series of continuous treatments, there would be significant reduction in the number of vital hair remaining within the treated body region.

- 5 c. Painlessness – there would be no pain associated with the hair removal method, or the level of pain and/or discomfort associated with hair removal would be insignificant enough to facilitate broad adoption of the method.
- d. Negligible side effects and damages – there would be minimal and
10 timely transient side effects or damages – both short term and long term - to vital biological tissues beyond the hair mechanism tissues being treated, and any side effects should be transient and preferably disappear within no more than a few days.
- e. Convenience – an individual desiring to permanently remove
15 his/her unwanted bodily hair, should be able to conveniently do it by his self, without the direct or indirect assistance of other individuals and/or hair removal professionals, at any location and time desirable, and,
- f. Low operational cost – the overall cost of treating all unwanted
20 bodily hair of a desired body organ and/or all body organs of a single individual, inclusive of all associated direct and indirect expenses such as cost of device, depreciation of device, cost of disposables / consumables and cost of third party professional labor, should not substantially exceed the cost of short term hair
25 removal methods.

Within the hair base, the papilla and hair growth zone (e.g. germinal matrix) play a key role in the hair re-generation and/or re-growth mechanisms. In support of its variety of roles and the hair regeneration / re-growth mechanisms, the papilla
30 integrates tiny blood vessels, which feed the hair regeneration / re-growth mechanisms. Thus, the optimal long term and/or permanent hair removal method would enable a well targeted and full destruction of only the plurality of hair papilla and hair growth zone within the desired body surface in which hair

needs to be removed, without negatively affecting any other soft tissues supporting and/or surrounding the hair follicle and/or the hair base.

5 A broad range of attempts have been made to utilize the hair as a wave guide for the propagation of different energy types to the area of the hair root, and as a result, generating sufficient irreversible damage to such region. Following these attempts, it has been scientifically discovered, that human hair has very poor conductivity to almost all types of energies, including: laser light, electromagnetic radiation in the radio frequency range and electrical current. Acoustic energy has
10 been discovered to be the type of energy for which the hair fiber material presents the highest level of conductivity, compared with other types of energy. The frequency of such acoustic energy can range between 10 kHz and 100 MHz. Other parameters of acoustic energy, such as amplitude, transmission mode, etc. also materially vary.

15 There are significant differences in direct and/or indirect effects, where acoustic energy is utilized, in a broad range of physical characteristics between the hair fiber material and its supporting and/or surrounding soft biological tissues. These acoustic characteristics include, but not limited to: velocity, conductivity, attenuation and impedance, and to thermal properties of hair, whether
20 independent or resulting from acoustic energy transfer, such as latent heat capacity, specific heat, etc. Part or all of such differences, and its resulting direct or indirect effects, could be potentially utilized to the development of new devices and methods for long term or permanent hair removal.

25 There exists a broad spectrum of prior art regarding a wide variety of devices and methods regarding hair removal. A relatively small portion of such prior art relates to the utilization of ultrasound technology for hair removal. From such prior art, the following are some notable examples: "Method and Apparatus for
30 Hair Removal" (WO 01/13757 A1); "A Method and Device for Affecting an Object by Acoustic Radiation (WO 01/26735 A1), "Method and Device for Hair Removal" (WO 00/21612 A1), "Vibration Depilator" (JP2001029126A2), and, "Depilation Device" (JP8154728A2).

GENERAL DESCRIPTION OF THE INVENTION

5 The present invention presents a device, its components and the method used for the automated, continuous, concurrent and noninvasive removal of at least one hair within hair surfaces designated for removal, by utilizing the direct and/or indirect effects of acoustic energy for generation of sufficient tissue damaging effects to the hair biological regeneration mechanisms and as a result, sufficient detachment of the hair from its root.

10 For the purpose of this document, acoustic energy and ultrasonic energy are used interchangeably.

15 According to well known scientific data, the exposure of the hair root to temperatures in excess of 70 degrees Celsius for 1 second or longer causes long term and sometimes permanent damage to the hair root. Similar damage will be caused by exposure of the hair root to temperatures in excess of 76 degrees Celsius for 0.3 second or longer, or by exposure to temperatures in excess of 62 degrees for 3 seconds or longer. This data is important in
20 understanding the nature of the present invention.

In order to generate similar temperatures and highly focused damage in the hair root / papilla without damaging other important tissues and sub-organs surrounding the hair shaft and bulb, the hair itself is used as a waveguide to
25 direct acoustic energy, which translates further into thermal energy, into the hair bulb / papilla. In order to generate such sufficient thermal effect, and while taking into account the physical and acoustic characteristics of the hair, a significant level of acoustic power density – greater than $100\text{W}/\text{cm}^2$ – needs to propagate through the hair in order to generate such desired damage at the
30 hair root. Because the average hair diameter is about 85 Microns, the acoustic power generated by, for example, a 1 cm^2 piezoelectric transducer plate, needs to be focused and concentrated by several orders of magnitude in

order to effectively propagate through the length of an average hair, and cause the desired damage to the hair root. Furthermore, even with effective concentration of acoustic power density generated by a typical piezoelectric transducer, without effective impedance matching between the transducer, the
5 focusing element and the hair shaft, a material part of the acoustic energy originally generated will be lost.

Thus, the present invention describes the design and method, which take into account and optimize the integration, synchronization and acoustic
10 characteristic matching of 3 key components of a hair removal device based on the generation and absorption of ultrasound energy by the hair root:

- Acoustic energy generator component
- Acoustic energy concentrator component
- 15 • Hair gripping and orientation component

The acoustic energy generator component can be comprised of many materials and shapes. It can be compacted into a very small size, so that it could be incorporated within a hand held device.

20

The acoustic energy concentrator component can be also comprised from a variety of materials and shapes. The preferred general shape of the concentrator is that of a horn made of a set of cylindrically shaped elements, connected in series to one another, the diameter of which is stepped down
25 starting from that attached to the acoustic energy generator, all the way to the last element where the highest power density is obtained. In another preferred embodiment, the concentrating horn is made in a conical shape, with its side linearly tapered. Yet, in another preferred embodiment, the conical horn side could be tapered in an exponential form. In a further preferred embodiment,
30 the concentrator could be made from a set of horns of same or different shapes, attached or built in series to one another, each one concentrating the ultrasound power density into the next horn element in line. , The length of the concentrator assembly is preferably a half wavelength of the ultrasound

radiation which has to be concentrated and in certain cases could be made in multiples of the half wavelength. It should be noted that the acoustic energy concentrator does not have to be cylindrically symmetrical. Furthermore, in order to effectively concentrate the acoustic power density radiated by the acoustic energy generator into the tip of the concentrator element which
5 needs to have a diameter of the same order of magnitude as that of the average hair, the concentrator shall preferably be made in a cone shape, and its side have at least one angle, preferably several angles, preferably following an exponential form, which effectively concentrate the acoustic energy into the
10 tip with minimal energy losses and adverse effects.

The hair gripping and orientation component is preferably made as a part of the concentrator element, or as a separate component attached to the acoustic energy concentrator component.

15 The materials from which the components are made are selected for minimal loss of acoustic energy by absorption. Furthermore, the components are attached to one another by use of impedance matching layers formed from materials of known acoustic impedance, as known in the art, where required.

20

25 DETAILED DESCRIPTION OF THE INVENTION

Acoustic Energy Concentrator

The vibrating motion generated by the acoustic energy transducer is normally too low for practical use and so it is necessary to magnify or amplify this motion. In terms of ultrasonic power density, the power density generated by the transducer has to be magnified or concentrated. This is the function of the
30 horn which, like the transducer, is a resonant element in the compression

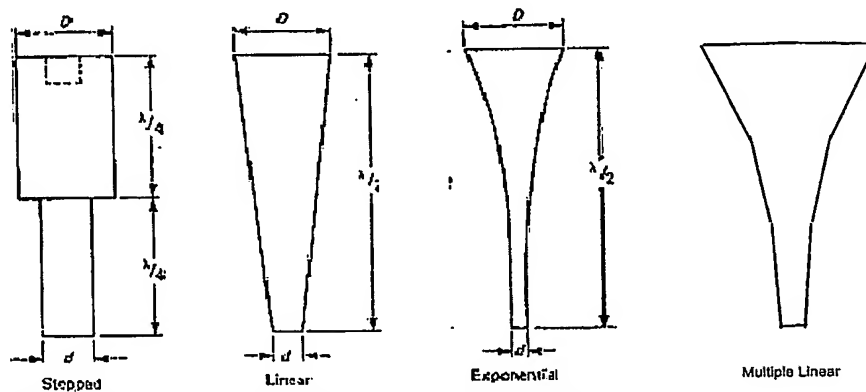
mode. Normally, these are half a wavelength long, although, they can be designed in multiples of half wavelengths. This can also be achieved by screwing or otherwise attaching one horn into the other thereby building up the overall length.

5 Three types of horn designs are shown in sketch 1.

(a) Stepped cylindrical shape: For this design the magnification factor is given by the ratio of the end areas. The potential magnification is limited only by the dynamic tensile strength of the horn material. This is a useful design and easy to manufacture.

10 (b) Linear tapered conical shape: Simple to make but its potential power density concentration is limited.

(c) Exponential tapered conical shape: This design offers higher magnification factors than the linear taper. Its shape makes it more difficult to manufacture but its length coupled with a small diameter at the working end makes this



15 design particularly suited to micro applications.

Sketch 1. Horn shaped concentrators. (a) Stepped cylindrical shape; (b) Linear tapered conical shape; (c) Exponential tapered conical shape; (d) Multiple linear tapered conical shape following exponential form

20

Hair Directing Means

The means by which at least one hair is gripped and directed to preferred orientations so that it can be inserted into guides that lead to the ultrasonic device port is selected from the list below, or made from a combination of elements from the list:

5

1. Combing with or without a fixing compound, such as a spray or grease that make the hair more compatible for the effective transfer of the ultrasonic energy via increased area of contact, adherence, added strength and providing matching impedance properties. The addition of
10 the fixing compound is applied to any of the other hair guiding methods described subsequently. Likewise, if the guiding device is not participating in the transfer of the ultrasound energy to the hair, it is of a different acoustic impedance as compared to that of the hair. This applies to all the guiding devices and methods described subsequently.

15

2. Using a mesh that, with slight lateral movement on the skin, traps hair within its holes. This exposes hair shafts in fixed locations. This method also provides the possibility of directing the hair into desired orientations.

20

3. Using a special comb that the groove in between each pair of adjacent teeth has a special form so that the tip of the encountered hair is directed toward the aperture of the wave guide "horn", as illustrated in Figure 1.

25

4. Using an air blower and/or air suction to direct the hair in a preferred direction or into desired holes or channels. An example of such holes is seen in Figure 2.

30

5. Trapping hair in specific locations by means of clamping devices such as the closure of the space between two surfaces or pins, example of which are presented in Figure 3.

6. Trapping hair with a hook like spring that is afterward pooled into a specially designed aperture in the "horn" for subsequent ultrasonic power transfer.

Hair Gripping Means

In principle, the device has an overall conical form (not necessarily straight) to concentrate the ultrasonic power from the piezoelectric surface of the ultrasonic energy generator to the hair shaft. The conical form has at least one angle, but preferable several angles, which facilitate effective concentration of ultrasonic energy from the piezoelectric surface to the hair shaft. It is comprised, at list in part, of material that has similar acoustic impedance to that of hair (matching impedance). The device facilitates, either or both, clamping the hair and having a matching impedance compound that enhances the propagation of acoustic energy to hair. It could be partially or fully adhesive, with the possibility of having disposable parts. The hair clamping device is driven and/or operated by any combination of mechanical, electrical, hydraulic and pneumatic means. All holding and clamping devices can incorporate grooves and/or holes in their bodies through which matching impedance gel or other compound can be pushed towards the hair shaft surface. The gel presence also enlarges the contact area and thereby improves the acoustic power transfer to the hair. The commercial device can incorporate any combination of the device principles presented here, and/or a multitude of them. Several principles that can be employed with examples of pertinent embodiments are presented subsequently.

1. As shown in Figure 4, a conical "horn" with a hole and a connection to a pneumatic pump is employed to suck, hold and discard the hair after its removal. Air suction from the upper part of the cone is used to suck the hair into the hole. The cone is made of one substance or several. One embodiment can be of a conical solid envelop with a shaft at the center. The volume encased by the cone envelop, the shaft and the piezoelectric plate can be filled with a matching impedance gel. Small holes in the shaft are used to squeeze some gel to fill the gap between the hair and the shaft. A connected source to the cone is used to supply the necessary gel with controlled pressure. Once the hair is removed, pneumatic suction and/or blowing is used to discard the hair and, if necessary, clean the

shaft for the next hair removal cycle. The air flow also cools the device if necessary.

2. Another embodiment is similar to the one shown in Figure 4, but without
5 the shaft. The conical envelop just has a hole at the tip (see figure 5), or a slot that can be closed, or made of several parts (can be also of folding parts). The removed hair is disposed by squeezing out some gel; or by clamping it externally and pulling it out. The device is thus connected to a controlled source of gel.
- 10 3. A conical horn, with at least one, but preferably multiple angles, that is made of two or more parts that is used to lock the hair for transfer of the acoustic power. One embodiment, shown in Figure 6, is of two parts that lock on the hair, with the possibility of the insertion of a matching
15 impedance compound in between the clamps. The gap between the parts adds surface area for cooling if necessary. The same principle is used with more than two parts, after it has proven to be advantageous for longitudinal acoustic energy transfer through the reduction of acoustic power losses. If made of multiple parts, it resembles a brush.
- 20 4. A solid cone with a groove within which the hair enters and is clamped in place by a clamp that has the shape of the groove, excluding the hair occupied space. An embodiment of such a device is shown in Figure 7.
- 25 5. A cone that has a non flat base, or piezoelectric shell, as shown in Figure 8. An example of such a surface would be a round section of a spherical surface or shell. Such a base exposes the cone tip to equal radial distance from the piezoelectric shell and thus provides a smoother conduit for acoustic power transfer, free of excessive wave interference.
- 30 6. A conical spiral spring with or without a central solid conical core, as shown in figure 9. Opening slightly the cone provides space for the entrance of hair. Releasing it traps the hair by elastic forces in the space

between adjacent surfaces. Matching impedance gel is used to fill the hair gap and provide better acoustic power transfer to the hair.

7. A solid conical core with a sectioned conical shell around it, as shown in Figure 10. Closure of the shell parts clamps the hair.

8. The device has cooling and/or thermal insulation capabilities to protect the skin and the device from extensive heating. This is in the form of cool air blowing and adding thermal insulation in between the device and the skin.

Control Mechanism

The device has at least one control mechanism, but preferably more than one control. These controls provide for smoother operation and longer life of the device. It minimizes unnecessary heating. If necessary it should control the temperature and the maximum duration of each hair removal cycle. The control, if necessary, senses if hair is present or clamped, before releasing the acoustic power for the destruction of its papilla. This can be achieved by several techniques, described subsequently.

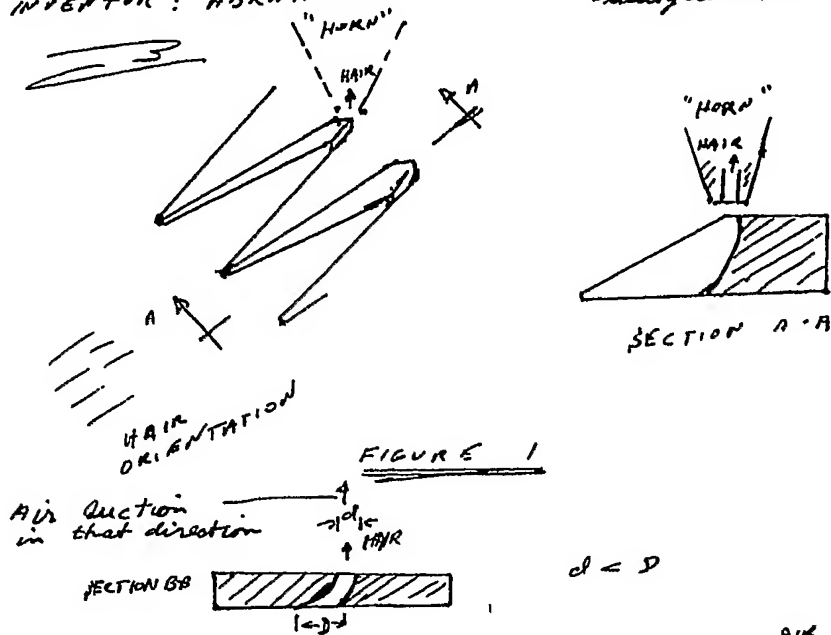
1. Mechanical sensing of the gap where the hair is supposed to be clamped or held.

2. Control by sensing the electrical resistance change owing to the presence of a hair.

3. Control by optical means, where the hair breaks the path of a light or electromagnetic wave beam.

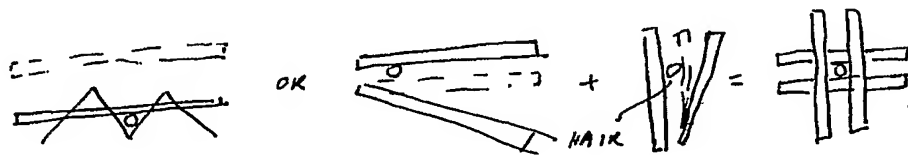
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Identification # 9608441



BLOWING AIR TO ORIENT
HAIR IN THAT DIRECTION

FIGURE 2



INVENTOR: ABRAHAM DAYAN Identification # 49608441

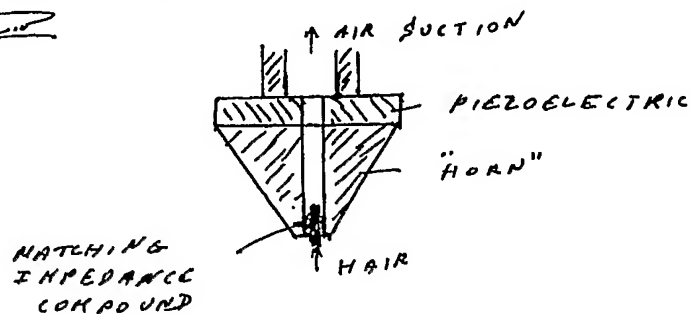


FIGURE 4

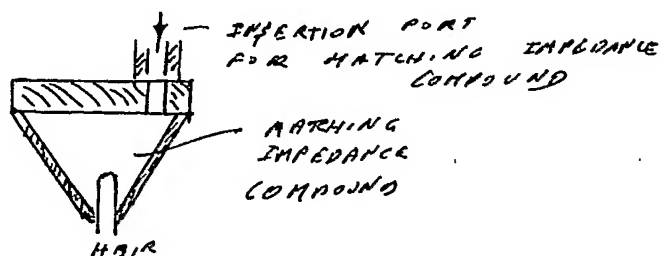


FIGURE 5

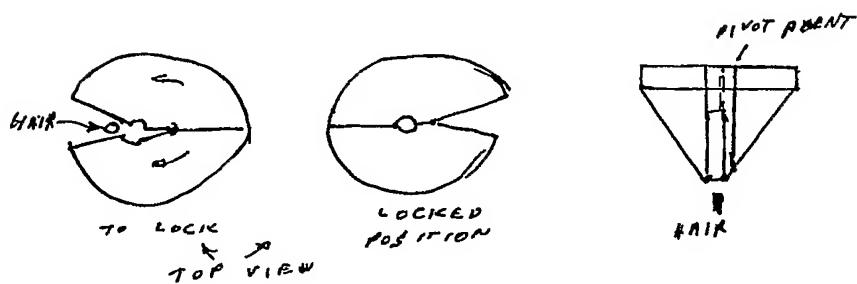


FIGURE 6

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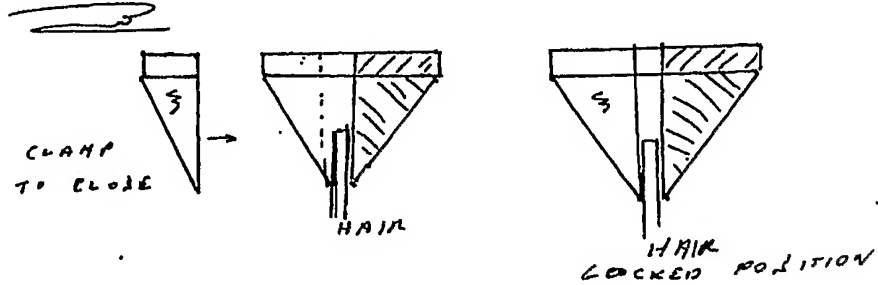


FIGURE 7

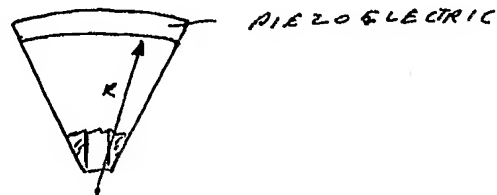


FIGURE 8

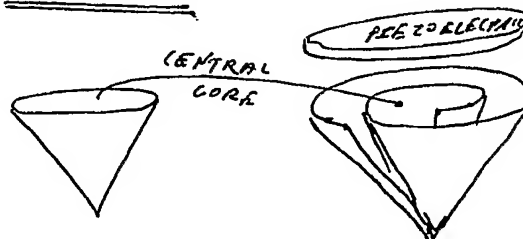


FIGURE 9

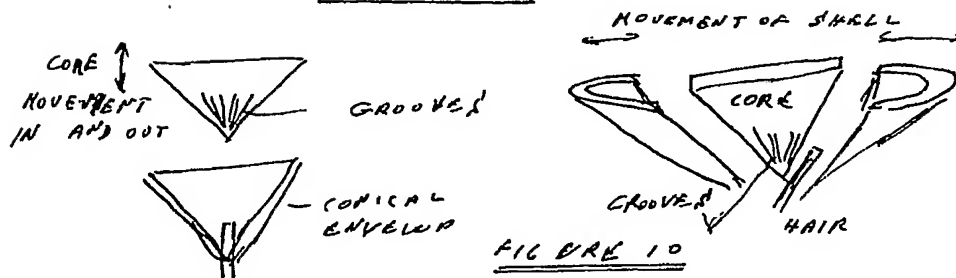


FIGURE 10

Another preferred embodiment of the present invention

The device comprises a hand-held unit, on which a set of hair grippers are located (fig. 11). While the unit is being positioned over a person's skin, in closed proximity, the grippers grip and semi-lock hair shafts protruding from the skin's surface. Each gripper is attached to an ultrasound transducer, and the ultrasound energy emitted by the transducer is focused by the gripper and/or by an ultrasonic concentrator attached to the gripper, into the hair shaft, which transmits further some of the energy into the hair's root, or the papilla. The energy absorbed by the papilla causes increase in the papilla's temperature, to a level which causes necrosis of the papilla, thus enabling the removal of the hair and/or causing a long term damage to the hair.

The grippers are designed each in a multi-angle cone shape, as discussed above in the Acoustic Energy Concentrator section, with at least one semi-spiraling groove running along the cone side from the cone tip all the way to the cone's base. The ultrasound transducer, in the form of a parallel plate, is designed to emit ultrasound energy efficiently in a selected frequency within the range of 50kHz-25MHz from the large-area sides of the plate. Its two sides are connected to a power supply, and the transducer assembly is designed to emit between 10mW/cm² and 25W/cm² of ultrasound energy from each of its wide-area surfaces. The transducer is attached to the base of the cone in a way that maximizes power transfer from the transducer into the cone, as known in the art, with minimal reflections. The cone dimensions are designed such that the ultrasound power transmitted into the cone's base is focused by reflection from the cone's surface towards the cone's tip. It means that each of the cone angles (twice the angle between the cone axis and the cone surface) is smaller than 90 degrees, i.e. the cones base diameter is smaller than twice the cone's height.

In a preferred embodiment the cone could be slowly rotated around its axis during operation in order to grip, attach and "lock" hair shafts into the groove. Furthermore, the edge of the groove could be protruding outside of the cone's surface such that the protrusion will assist in the attachment of hair shafts into the groove.

The figures provide different views of the gripper and the ultrasound transducer.

Dimensions:

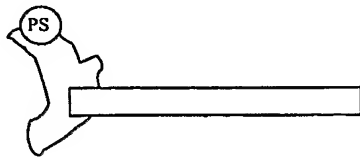
Figure 11

5

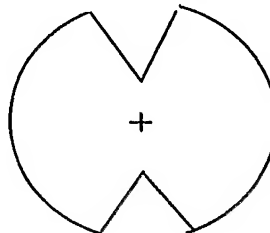
Base diameter about 3-10mm, cone height about 3-10mm, groove depth starts at about 100 microns near the tip of the cone, going up to about 0.5-2mm near the cone's base.

- 10 Estimated thickness for the transducer's plate is about 1mm for emitting ultrasound waves at about 1MHz. Ultrasound waves at other frequencies require different plate thickness for optimized emission of ultrasound energy, as known in the art.

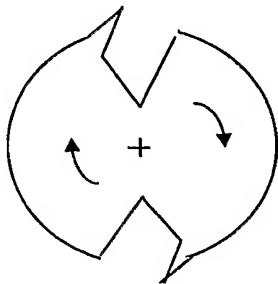
Ultrasound (US) Transducer's plate side view, connected to power supply (PS)



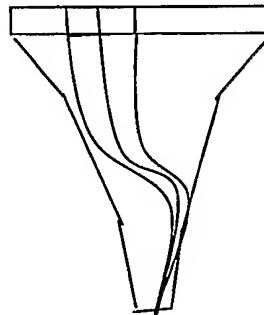
Cone's base view (top view) and US Transducer's plate top view showing two grooves.



Cone's cross section showing rotation direction and protrusions at each of the grooves' edges.



Cone's side view, US Transducer's plate on top, and the semi-spiraling sliced groove



- The cone material is selected such that there will be minimal reflection of ultrasound energy back into the ultrasound transducer plate from the cone's base, and minimal reflection of ultrasound energy back from the cone-hair shaft interface, as well as minimal absorption of ultrasound energy within the cone. Suitable materials are, for example, Titanium alloys, Aluminum, Aluminum-Bronze and Stainless Steel. Ultrasound gel could be used in the groove to improve holding of the hair shaft inside the groove together with improving the transfer of ultrasound energy from the cone into the hair shaft.
- 5
- 10 Yet, another preferred embodiment of the present invention is described in the Appendix.

It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrated embodiments, and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof. The present embodiments are therefore to
 5 be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims and therefore intended to be embraced therein.

10

CLAIMS

69. A method for the removal of hair comprising the steps of:

- 15 • selecting a skin surface;
- predisposing for gripping at least one hair within said selected skin surface;
- gripping said hair;
- acoustic coupling said hair for acoustic energy transfer;
- 20 • propagating acoustic energy, via said hair, into the roots of said hair, for generation of long term damage to said hair.

70. A device for causing a long term damage to a hair on a surface of a
 25 body, comprising:

- a gripper for gripping said group of hair;
- an acoustic energy generator; and
- an acoustic energy concentrator,
- 30 • such that the acoustic energy generated and concentrated is transferred to said hair and causes a long term damage to said hair.

Another preferred embodiment of ultrasonic focusing transducer utilized for the present invention

The following illustrations describe the ultrasonic focusing transducer whereat a bundle of conical fiber-optics is used to transmit and to focus the acoustical energy from the piezo crystal toward the pointed target:

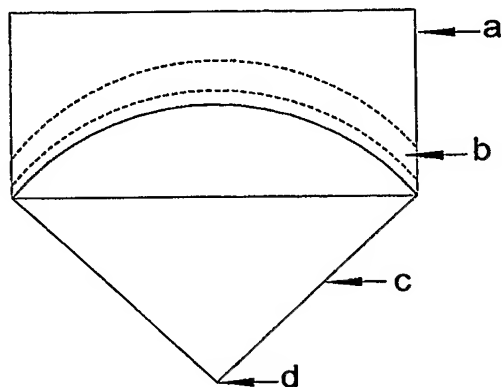


Figure 12. General design configuration

- a. Transducer housing
- b. Piezo ceramics
(Active element)
- c. Focusing horn
- d. Point of maximum
acoustic intensity

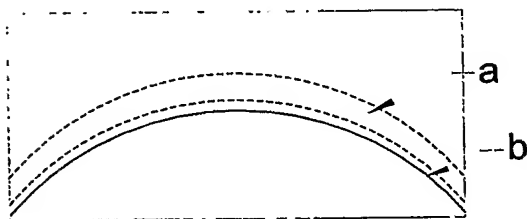


Figure 13. Scheme of coupling

- a. Air backed sphere
shape piezo-
ceramic
transducer

b. Coupling Layer

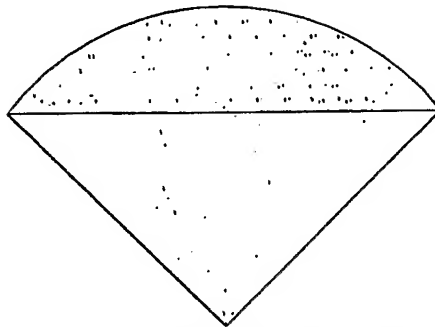


Figure 14. A wave guiding horn for High Frequency acoustic energy concentration

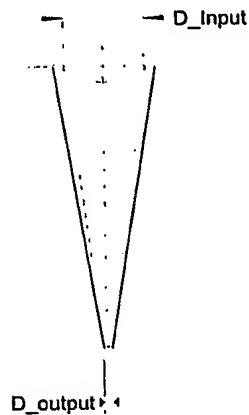


Figure 15. Single element of the acoustic energy concentrator.

It is constructed from the polymer fiber, widely used as an optical waveguide. Multiple of these elements, tightly banded together, form the horn type acoustic energy concentrator. Maximum Intensity is achieved at the output of the proposed horn. Efficiency of the energy concentration relates to $(D_{input} / D_{output})^2$. The higher the frequency, the smaller the D_{input} should be. The horn length shall be equal to the radius of curvature of the transducer.

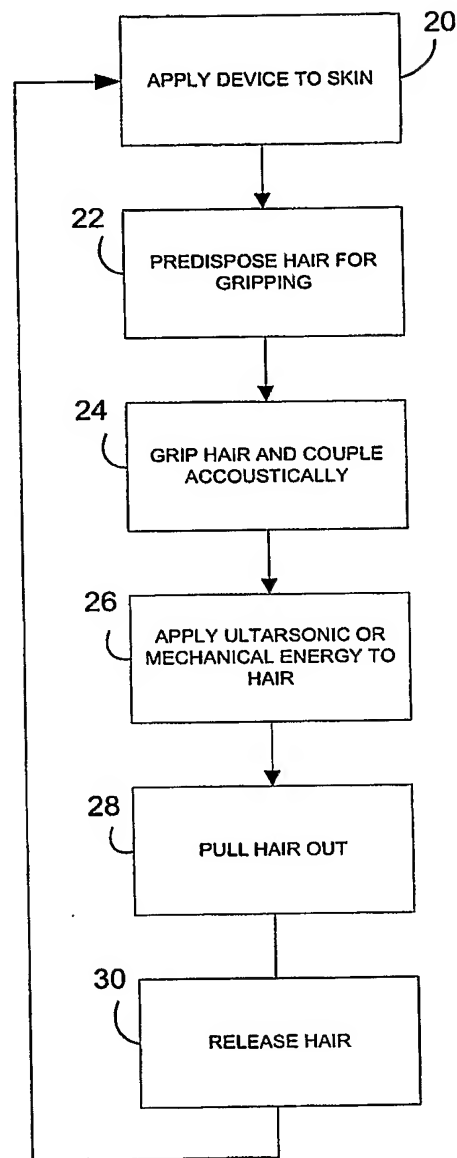


Fig. 1

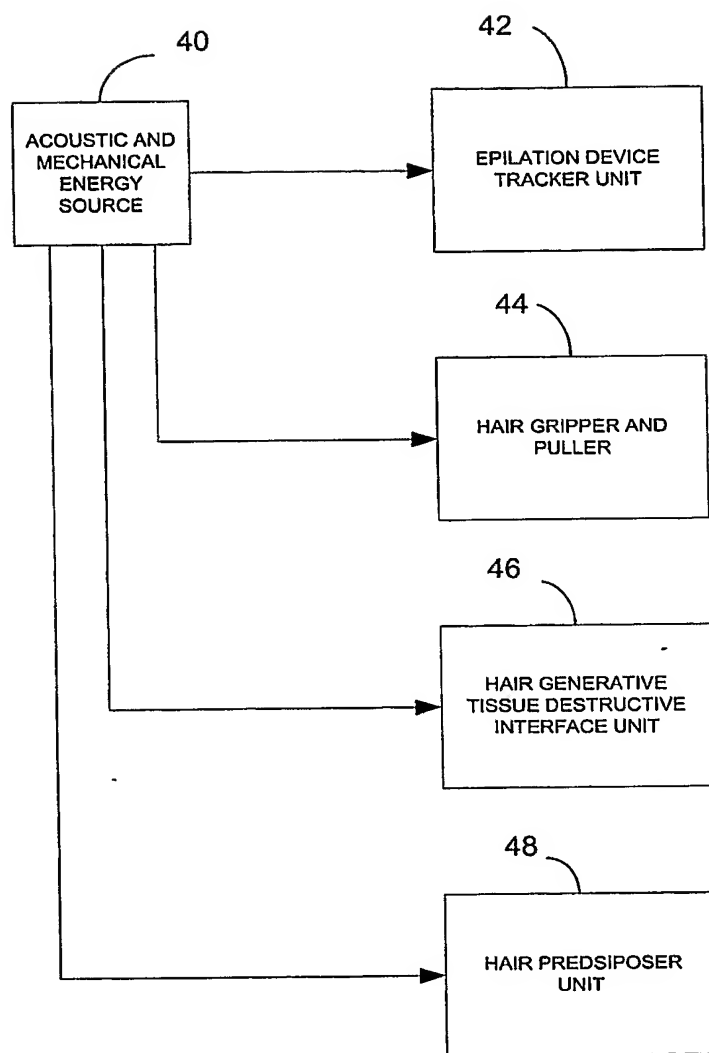


Fig. 2A

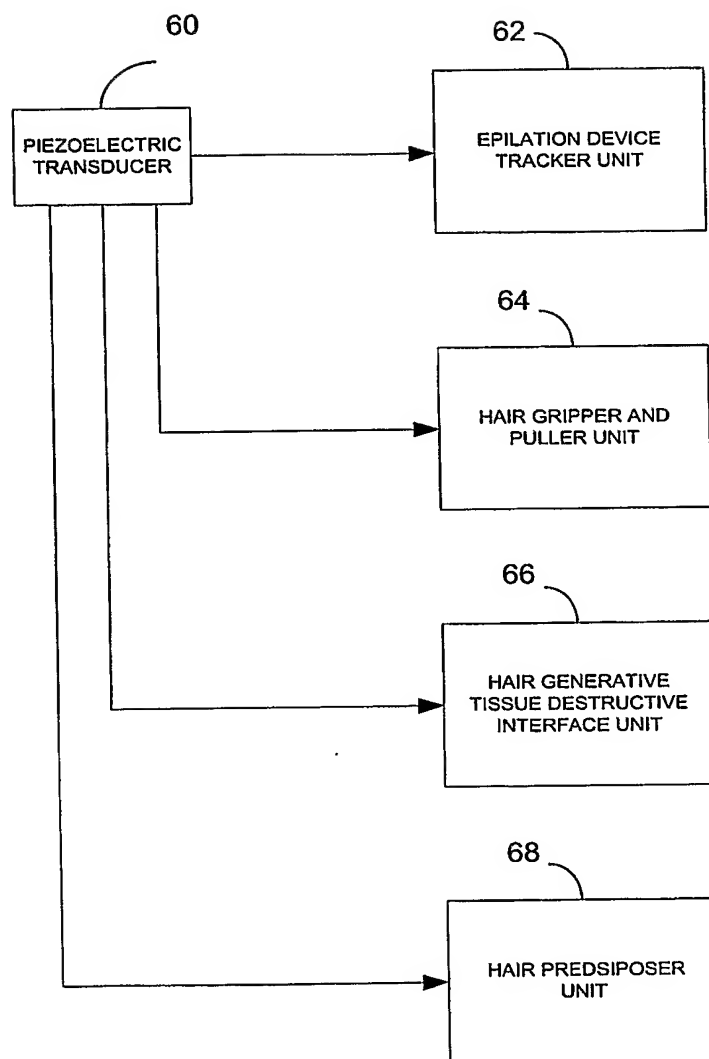


Fig. 2B

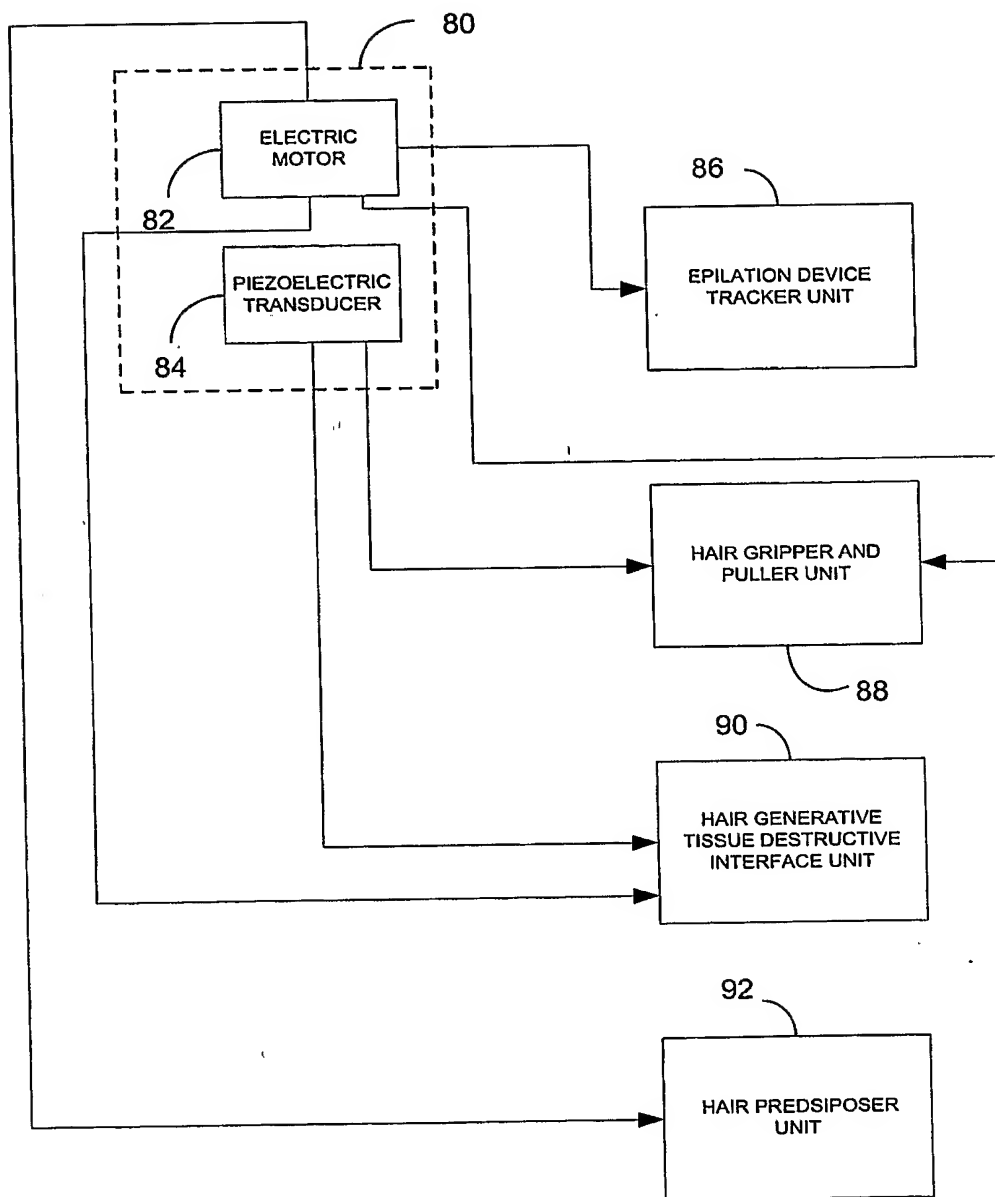


Fig. 2C

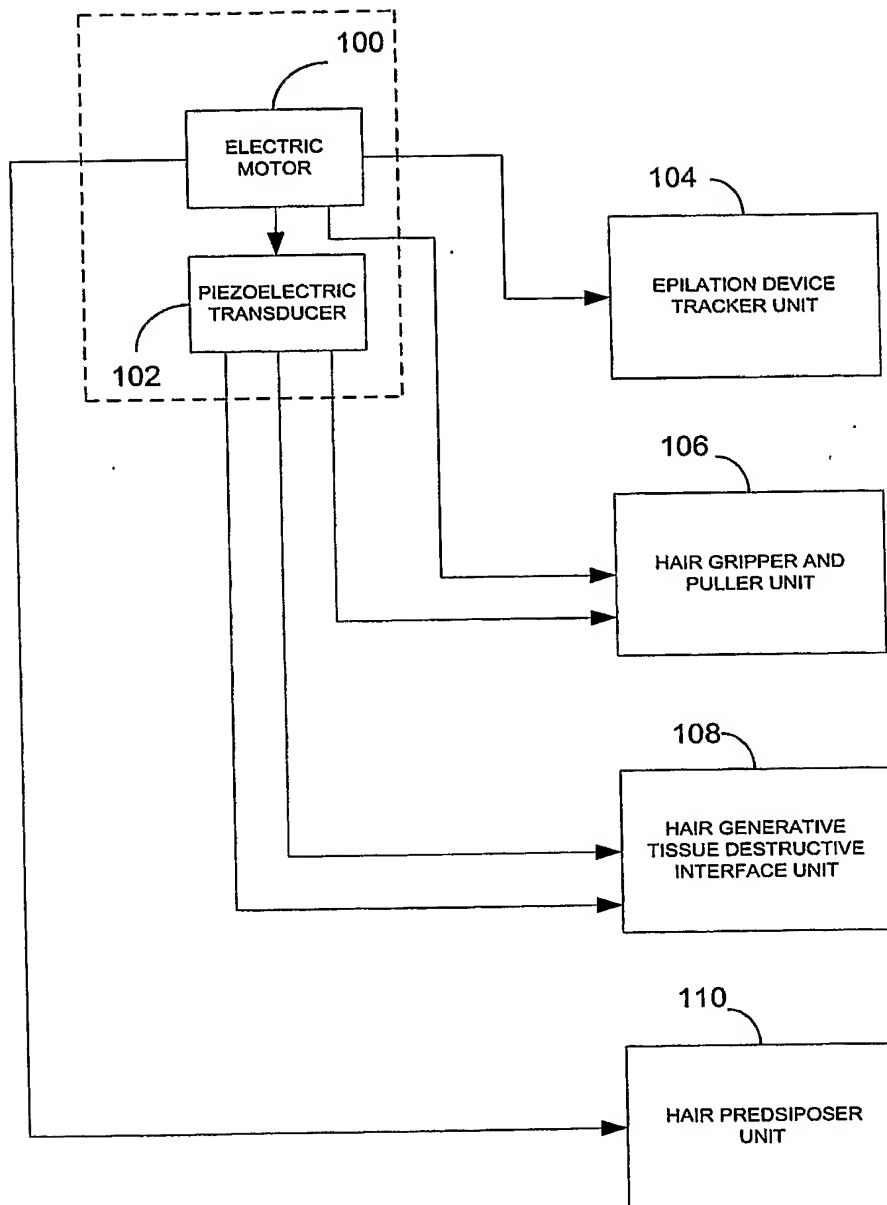


Fig. 2D

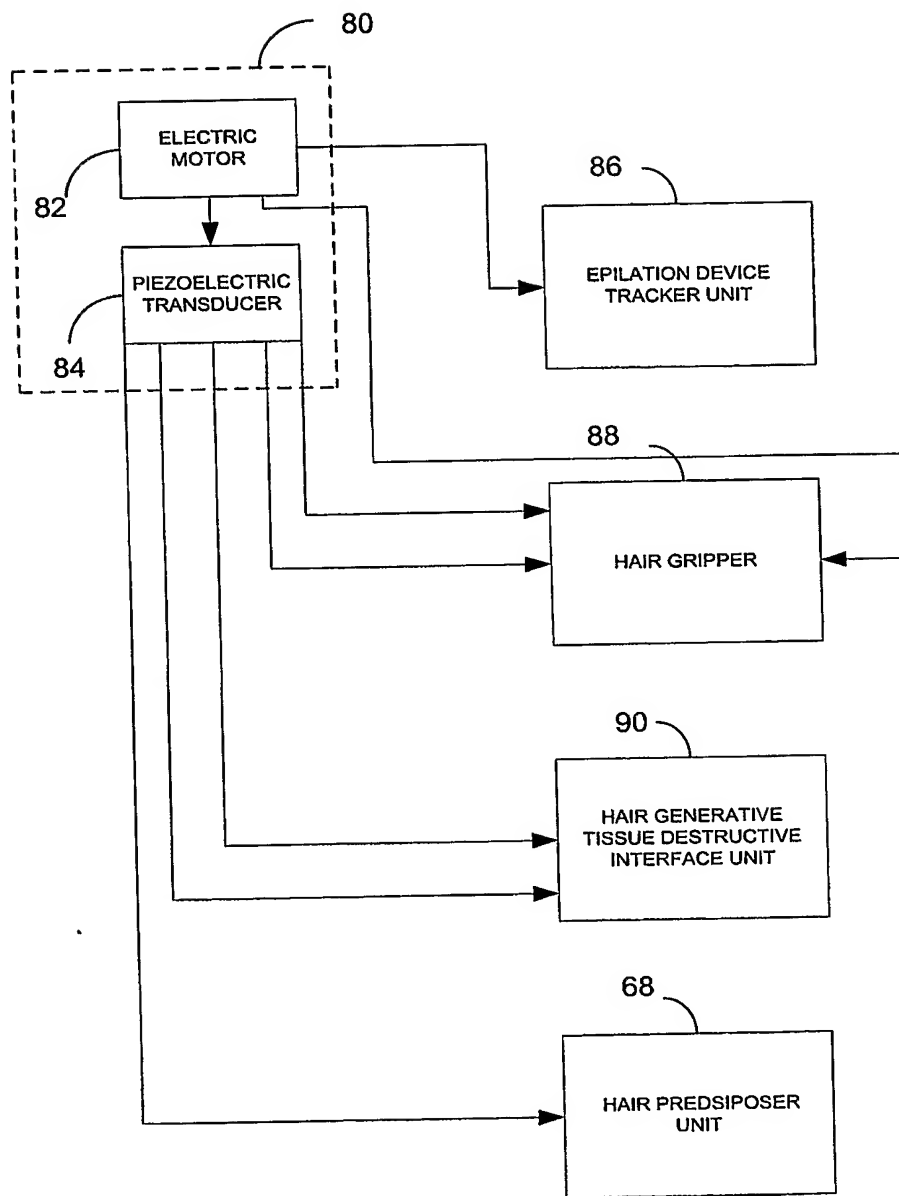


Fig. 2E